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Original Article

The relationship between physical activity, stress, life satisfaction and sleep quality

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Abstract:
Problem statement: The factors that related to sleep quality are diverse. A body of studies examined physical activity and stress, life satisfaction and sleep quality, but to date no studies investigated the association amongst them regarding the age. Little is known about the difference of stress, life satisfaction and sleep quality between physically active and non-active people. Approach: A cross-sectional study was launched with 292 participants, who answered a battery of questionnaires formulated by Qualtrics online research platform.
Purpose: The aim of this study was to present the relationship between demographic factor (e.g. gender, age) with physical activity, life satisfaction, stress and sleep quality.
Results: The prevalence of moderate (69.9%) stress was the highest compared with those reporting low (24.7%) and high (5.5%) stress. Stress and life satisfaction were significantly correlated with sleep quality ($p < .05$), but only stress associated significantly with sleep quality (p<.00, SE=.03, B=.43). In addition, there was no significant relationship between sleep quality and physical activity. Sedentary lifestyle is not beneficial for life satisfaction, and people who carry on sedentary lifestyle is more easily to get stressed. Conclusion: It is suggested to take into consideration about age when discussing the mechanism between physical activity and sleep quality. The effect of physical activity on sleep quality among healthy population needs more evidence. Future studies are suggested to classify the substantial benefits of specific physical activity types on stress and sleep quality.
Key words: physical activity, stress, life satisfaction, sleep quality, PSQI

Introduction

The spectrum of physical activity on health issues is wide according to epidemiological evidence (Laporte, Adams, Savage, Brenes, Dearwater & Cook, 1984). To our best acknowledge, physical inactivity has a major effect on non-communicable diseases worldwide (Lee et al, 2012). In addition, participating in physical activity affects psychological well-being (Norris, Carroll & Cochrane, 1992). Moreover, physical activity is often recommended as a strategy for managing mental pressure, and health promotion program is frequently used as solutions (Nguyen, Unger, Hamilton & Spruijt, 2006). World Health Organization (WHO) (2010) recommended physical activity in primary prevention of noncommunicable diseases (NCDs) at population level. The prevalence of regular physical activity, stress, life satisfaction varies in different regions. Even though the benefits of physical activity were highly announced, its effect on sleep lacks of quantitative investigation in general population.

Physical activity, stress, life satisfaction and sleep quality have demonstrated increasing attention in academic research in recent years. Early studies have reported positive effectivity of physical activity on public health (Pate et al, 1995). According to WHO (2016), in the document of global recommendations on physical activity for health, which emphasized that adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week.

Academic stress for college students has drawn considerable attention, but job-related stress has been a neglected area of research (Beehr & Newman,1978). The life satisfaction was declined (Proctor, Linley& Maltby, 2009) and sleep quality showed decreasing tendency (Pilcher, Ginter & Sadowsky, 1997). Stress and poor sleep quality were potential risks for health, specifically, stress was associated with increased sleep complaints and low level of perceived health (Gerber, Hartmann, Brand, Holsboer-Trachsler, & Pühse, 2010). Sleep quality has been identified as key issue for health, however, the awareness of sleep hygiene was low (Voinescu & Szentagotai-Tatar, 2015).

Different levels of physical activity imply a differential effect on stress-related neurophysiological systems in response to psychosocial stress (Rimmele et al, 2009). In addition, vigorous exercisers who exercise frequently were found cognitively younger than those inactive people (Clark, Long & Schiffman, 1999).

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Furthermore, individuals with high levels of physical activity are less likely to develop depressive illness than those people who carry out lower levels of physical activity (Kesaniemi et al, 2001). As indicated, physical activity level was consistently positive associated with health-related quality of life (Bize, Johnson & Plotnikoff, 2007). It is well known that age is a key factor to physical activity, physical exercise works well among elder population (Reid et al, 2010). Whereas, how age increase associated with physical activity has barely been mentioned in previous research.

Insufficient physical activity and sedentary behaviors are common in the society (Van, Paw, Twisk & Van, 2007). The proportion of 13–15-year-olds doing fewer than 60 minutes of physical activity of moderate to vigorous intensity per day is 80.3% (80.1–80.5); boys are more active than are girls (Hallal et al, 2012). Additionally, most college students did not meet the requested physical exercise volume which was assessed by physical activity guidelines (Huang et al, 2003). Nevertheless, insufficient sleep and irregular sleep–wake patterns have been extensively documented in younger adolescents and college students (Lund, Reider, Whiting, & Prichard, 2010). College students did not meet the sleep duration guidelines, 7 to 9 hours per day, for health issues (Hirshkowitz et al, 2015). An estimated 26% of adults reported frequent (≥14 days in the past 30 days) sleep insufficiency (Strine & Chapman, 2005). An American study illustrated that work overload was positively associated with the frequency of poor sleep quality (Knudsen, Ducharme & Roman, 2007).

Increasing number of studies have provided supporting evidence on the associations between physical activity, stress, life satisfaction and sleep quality in the past decade. Psychological stress and physical activity are believed to be reciprocally related, and they result in physically inactive (Stults-Kolehmainen & Sinha, 2014). As revealed in the Scottish Health Survey, any kind of daily physical activities were associated with a lower risk of psychological distress (Hamer, Stamatakis, & Steptoe, 2008). Stress is also a predictive factor for life satisfaction, moreover, the interaction between perceived stress and life satisfaction was associated with physical exercise (Fang, Huang & Hsu, 2018). But more evidence is needed to figure out how much exercise is necessary to trigger stress-buffer effects.

To date, several studies have worked out the benefits of physical exercise as mentioned above. However, one meta-analysis showed that in older adults, aerobic exercise (e.g. Tai chi) showed weak benefits for sleep quality (Du, 2015). How physical activity benefits sleep quality? Up to now, the association between different exercise intensity and sleep quality has not, though, hitherto been subject to explicit investigation. Furthermore, sedentary behavior, inactive lifestyle and active lifestyle may undergo different life satisfaction, stress, sleep quality. The association between physical activity, stress, life satisfaction and sleep quality were not elaborately stated. We hypothesize that 1) there is gender difference between physical activity, perceived stress, life satisfaction and sleep quality; 2) there is difference in perceived stress, life satisfaction and sleep quality between sedentary and non-sedentary life status; 3) physical activity, perceived stress, life satisfaction are associated with sleep quality, and the relationship between physical activity and sleep quality becomes closer with the increase of age. The purpose of this study was, firstly, to assess the level of physical activity, perceived stress, satisfaction with life, and sleep quality. Secondly, to investigate the interaction between physical activity, perceived stress, satisfaction with life and sleep quality and explore the predictive power of these factors on sleep quality.

Materials and Methods

Participants

The online questionnaire was sent to adults above 18 years old. Participants included 106 males (36.3%) and 186 females (63.7%). Responses were collected from both studying (49.7%) and working (46.2%) voluntary samples from 18 years old adults. One response was excluded due to missing data. Approximately twice more participants were single (62.7%) than those who married or living in a cohabiting relationship (37.3%).

Instruments

The questionnaire was composed by self-administrated demographic questions followed by a series of questionnaires on physical activity (PA), perceived stress (PS), life satisfaction (LS) and sleep quality (SQ). We collected biophysical data (e.g. age, gender, height, weight), and social characteristic data (e.g. marital status, identity, region). We calculated exercise volume by asking two questions: 1. How many times do you exercise (minimum 10 minutes each time) each week? 2. On the average, how many minutes you exercise each time? Physical activity, perceived stress, life satisfaction and sleep quality were assessed by International Physical Activity questionnaire short form (IPAQ-SF) (Craig CL.et al, 2003), Perceived Stress Scale (PSS) (Cohen et al., 1983) (Cohen, Kamarck & Mermelstein, 1994), Satisfaction With Life Scale (SWLS) (Diener, Emmons, Larsen & Griffin, 1985), Pittsburgh Sleep Quality Index (PSQI) (Buysee, 1989), respectively.

International Physical Activity questionnaire (IPAQ) comprises four elements: vigorous exercise, moderate exercise, waking and sitting. By asking the exercise frequencies and exercise duration per week, vigorous physical activity, moderate physical activity and walking were calculated, the sitting time was evaluated directly by the question: During the last 7 days, how much time did you spend sitting on a weekday? The physical activities were recorded in minutes in last week. High reliability ($\alpha > .80$) indicated good stability and reliability of the questionnaire, and criterion validity had a median p value of about 0.30, which was comparable to most other self-report validation studies (Craig CL.et al, 2003).

Perceived Stress Scale (PSS-10) is a classic stress assessment instrument with 10 questions. Each item in this scale asks about feelings and thoughts during the last month and is rated on a 5-point scale (0=Never, 1= Almost never, 2=Sometimes, 3=Fairly often, 4=Very often). Individual scores on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress. Scores ranging from 0-13 would be considered low stress; scores ranging from 14-26 would be considered moderate stress and scores ranging from 27-40 would be considered high perceived stress. The PSS-10 showed marginal satisfactory Cronbach's alpha values (α=0.69) (Andreou, 2011), and Cronbach's alpha above 0.7 was considered as satisfied.

Satisfaction With Life Scale (SWLS) is a 5-item scale designed to measure global cognitive judgments of one's life satisfaction. Participants indicate how much they agree or disagree with each of the 5 items (In most ways my life is close to my ideal; The conditions of my life are excellent; I am satisfied with my life; So far I have gotten the important things I want in life; If I could live my life over, I would change almost nothing.) items by using a 7-point scale that ranges from 7 strongly agree to 1 strongly disagree. Higher score indicates better life satisfaction. The SWLS has satisfactory inter-item correlations (r > .60), and reliability (α= .84) (Michael, Agathi, Christos, Eirini & Anastassios, 2017). Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month. The global PSQI score > 5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, p □ 0.001) in distinguishing good and poor sleepers (Buysse, 1989).

Data collection and analysis

A set of online questionnaires were distributed via smartphone applications (e.g. Facebook, Wechat etc.) and several online communities specially tailored to sports and physical activities (e.g. fitness and lifestyle.co.uk, freeads.co.uk, quertime.com etc.). All the participants were provided a written consent at the first page of the questionnaire before taking part in the study, and only by accepting the consent, the participants were allowed to complete the questionnaire. The consent letter appears at the first page of the questionnaire to inform the participants the terms and conditions to answer the questionnaire as well as the ethical permission. By clicking "YES", the participants were able to continue with the questionnaires. Data were collected in April and May 2018. Responses were excluded or partially excluded for the following reasons: 1) repeated responses; 2) abnormal responses(outliers).

We used SPSS 24 software (Chicago, IBM) to do the statistical analysis. In the present study, descriptive analysis was used to show the prevalence of physical activity volume, stress, life satisfaction and sleep quality. Independent t-test and one-way ANOVA was used to examine the gender difference of physical activity, stress, life satisfaction and sleep quality. Independent t-test was also used to examine stress, life satisfaction and sleep quality in sedentary (exercise more than 150 minutes per week) and non-sedentary groups (exercise less than 150 minutes per week). In order to test the correlations between physical activity, stress, life satisfaction and sleep quality, bivariate correlation was performed followed by linear regression analysis. At last, the relationship between physical activity and sleep quality in different age groups was tested by scatter analysis.

Results

The participants' mean age were at the end of their twenties at males (M=29.12, SD=7.72) and females (M=28.73, SD=7.47). In addition, the number of married or living cohabiting relationship is slightly less than the number of single participants for men 35/106(33%) and women 74/186(40%). The number of people who work and study were approximately the equal in the current study (men: 50/106(49%), women: 85/186(46%)).

Approximately seven out of ten participants had physical activity less than 150 minutes per week with physical exercise volume M=112.02 (SD=129.66) minutes per week. It is statistically significant that males (M=146.37, SD=155.52) do more exercise than females (M=93.85, SD=109.84) per week (p<.001). In addition, a majority of people (69.9%) suffering moderate stress, small amount of people (5.5%) were in high perceived stress, and low percentage (24.7%) of people reported low stress. Females (M=17.71, SD=6.06) presents much severer perceived stress than males (M=16.42, SD=5.70). The results showed that, males (M=4.62, SD=1.48) were more satisfying with life than females (M=4.53, SD=1.69). The mean score of PSQI for male is 5.70 (SD=3.21) and female is 5.13(SD=3.08) with more good sleepers (60.3%) than bad sleepers (30.7%) in the sample. Table1 shows the demographic characters of the participants.

Table1 Demographic characteristics and measured variables of the participants

Measures	Men	Women
Number of participants (n)	106	186
Age (M±SD)	29.12±7.72	28.73±7.47
Married or living in cohabiting relationship (n)	35/106(33%)	74/186(40%)
Workers (n)	50/106(49%)	85/186(46%)
Physical activity (minutes, M±SD)*	146.37±155.52	93.85±109.84
Perceived stress (M±SD)	16.42±5.70	17.71±6.06
Life satisfaction (M±SD)	4.62±1.48	4.53±1.69
Sleep quality (PSQI score, M±SD)	5.70±3.21	5.13±3.08

*NOTE: Males do more physical activity than females (p<.001).

To test the associations of physical activity, stress, life satisfaction and sleep quality, bivariate correlation analyses were conducted followed by linear regression, the results were presented in Table 3 and Table 4. Stress and life satisfaction are correlated with each other with statistical significance (p<.001), and both stress(p<.001) and life satisfaction (p<.05) are significantly correlated with sleep quality. According to the results of linear regression, only stress was statistically negatively associated with sleep quality with a relatively high predictive power (p<.001, SE=.03, B=.43), life satisfaction did not show predictive power (Beta=.009) with sleep quality. Physical activity did not show any significance with sleep quality (p>.05) in statistical analysis.

Table 2 Correlations between the amount of physical activity, stress, life satisfaction and sleep quality by bivariate correlation analysis

		Physical activity	Stress	Life satisfaction	Sleep quality
Physical activity	Pearson Correlation	1			
	Sig. (2-tailed)				
Stress	Pearson Correlation	-.07	1		
	Sig. (2-tailed)	.27			
Life satisfaction	Pearson Correlation	.10	-.34**	1	
	Sig. (2-tailed)	.09	.00		
Sleep quality	Pearson Correlation	-.01	.26**	-.14*	1
	Sig. (2-tailed)	.9	.00	.01	

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table3 Associations among the amount of physical activity, stress, life satisfaction and sleep quality by linear regression.

Model	Unstanderdized coefficients		Standerdized coefficients			95% Confidence interval for β	
	B	Std. Error	Beta	t	Sig.	Lower bound	Upper bound
Physical volume	.000	.001	.009	.165	.869	-.002	.003
Stress	.228	.033	.436	6.944	.000	.164	.293
Life satisfaction	-.026	.031	-.052	-.827	.409	-.087	.035

Dependent variable: PSQI = Pittsburgh Sleep Quality Index

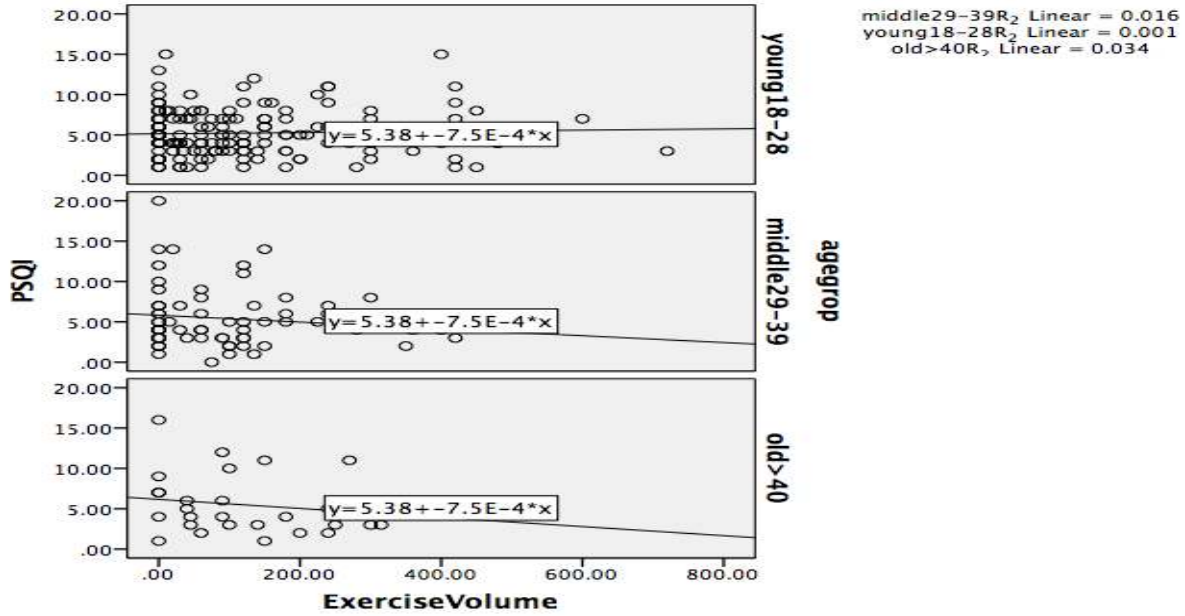
Table 4 illustrated whether there is difference in life satisfaction/perceived stress/sleep quality between people who do exercise and who do not by using independent t-test analysis. We define people who do not do physical activity as sedentary group, people who do physical activity as non-sedentary group (exercise volume more than 150minutes per week). Life satisfaction (p= .02, Cohen's d=.48) and perceived stress (p= .04, Cohen's d= -.27) were significantly different between participants who do physical activity and who do not. No significant association was found in sleep quality between sedentary lifestyle and non-sedentary lifestyle (p>0.05, Cohen's d= -.12).

Table 4. Difference of life satisfaction/perceived stress/sleep quality between sedentary and non-sedentary individuals by independent t-test.

	Non-sedentary group (n=76)		Sedentary group (n=186)		Sig.	95%CI		Effect size (Cohen's d)
Variables	M	SD	M	SD		Lower	Upper	
Life satisfaction	4.77	1.57	4.22	1.65	.02	-.98	-.11	.48
Perceived stress	1.74	.52	1.88	.51	.04	.01	.28	-.27
Sleep quality	1.37	.48	1.43	.50	.41	-.08	.19	-.12

No association was found between general physical activity and sleep quality as mentioned above, thus, the association between physical activity and sleep quality in different age groups (young: 18-28 years old, middle: 29-39 years old, old: above 40 years old.) was investigated by scatter analysis as an additional analysis. Figure 1 showed that with the increase of physical activity volume, there is almost no change in sleep quality in young age populations (Linear=.001). Nevertheless, middle aged population (Linear=.016) and old population (Linear=.034) showed stronger effect between physical activity and sleep quality.

Figure 1 Correlation between physical activity and sleep quality at different age groups



Discussion

This cross-sectional study unfolded the relationship amongst physical activity, stress, life satisfaction and sleep quality in consideration with the demographic characteristics. Gender difference in physical exercise is significant, males do more exercise than women. However, Trost (2007) found that the magnitudes of gender difference in physical activity is moderate. The reason of the gender difference may due to the different physical activity motivations (Kilpatrick, Hebert & Bartholomew, 2005). Even though there is no statistical significant gender difference in stress and life satisfaction between men and women, women live in more stressful life status than male, moreover, women showed less satisfaction with life compared with men. Our result supported the previous study that life satisfaction is gender independent with marginal exceptions and having no partner implies for relatively low level of satisfaction (Fugl-Meyer, Melin, & Fugl-Meyer, 2002).

Previous study elaborated the effect of stress in predicting life satisfaction showed that high perceived stress predicts low satisfaction (Extremera, Durán & Rey, 2009). In addition, perceived stress was found to be a good predictor of life satisfaction for young adults (Hamarat, 2001). In the present study, we found that stress and life satisfaction are closely correlated, and the predictive effect to sleep quality is different. Bivariate correlation showed that stress predicted stronger predictive power on sleep quality than life satisfaction. The evidence from linear regression showed that only stress is significantly associated with sleep quality. However, in PSQI scale, there are seven components of sleep quality, stress influences different aspects of sleep quality (Fortunato & Harsh, 2006).

The stress status and life satisfaction are different between sedentary and physically active individuals, but there is no difference in sleep quality, no positive result was found in the association between physical activity and sleep quality in our study. We did not take into the people who do physical exercise less than 150 minutes per week when categorizing the sedentary group in statistical analysis, which strengthened the statistical accuracy in data analysis. Our results supported the previous study which revealed that there is no correlation between sleep and daily activities in normal sleepers (Sexton-Radek & Pichler-Mowry, 2011; Youngstedt, 2003).

Nevertheless, even though the correlation was not significant between physical activity and sleep quality, we found that age played an important role as a mediator of the relationship between sleep quality and physical activity. With the increase of age, the relationship between physical activity and sleep quality becomes stronger and correlation between them becomes tighter. Prior research on older adults has mainly focused on investigating whether increasing levels of physical activity leads to improvements in sleep quality. Current researches proved that physical exercise interventions launched among older adults showed more positive effects on improving sleep quality than younger adults (Holfeld, & Ruthig, 2014; Benloucif, 2004). While, no study has examined the correlation between physical activity and sleep quality by the increase of age. Social rhythms (e.g. getting into or out of bed, eating, and adhering to a work schedule) have important implications for sleep among young adults rather than physical activity (Carney, Edinger, Meyer, Lindman, & Istre, 2006).

Although this study was fully prepared, there were unavoidable limitations. Firstly, the number of voluntary samples is small, which may be the obstacle in finding a meaningful relationship between physical activity and sleep quality. Secondly, the actual amount of physical activity was not clearly controlled in the questionnaire. Self-reported data in physical exercise can contain several potential sources of bias, which rarely be independently verified.

Conclusions

This paper addressed the associations between physical activity, stress, life satisfaction and sleep quality as well as putting demographic factors (e.g. gender, age etc.) into consideration. In the general population, no association was found between daily physical activity and sleep quality. Although we found that the association between physical activity and sleep quality becomes more intensive with age. Despite new efforts to explore the health effectiveness of physical activity, more research is needed to develop new exercise methods which would beneficially improve sleep quality.

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